REMARKS

In the Office Action, claims 1-42 were rejected. By the present Response, claims 1, 13, 14, 17, 18, and 37 are amended. Claims 5, 6, 24, and 35 are canceled. Upon entry of the amendments, claims 1-4, 7-24, 25-34, and 36-42 will be pending in the present patent application. Reconsideration and allowance of all pending claims are requested.

Objections to drawings

The Examiner objected to the drawings as failing to comply with 37 C.F.R §1.83(a) because they do not show every feature of the invention specified in the claims. In particular, the Examiner indicated that the convex, linear and plano-concave lenses of claim 6, for example, must be shown or the feature canceled from the claim. No changes have been made to the drawings. However, claim 6 has been canceled to overcome the Examiner's objections to the drawings. Similarly, the Examiner indicated that the discrete, divergent beams in the azimuthal and azimuth-depth plane and the various aperture shapes of, for example, claim 24 must be shown. No changes have been made to the drawings. However, claim 24 has been canceled to overcome the Examiner's objections to the drawings.

Rejections Under 35 U.S.C. §112

Claim 36 and 42.

Claims 36 and 42 stand rejected under 35 U.S.C. §112 first paragraph as failing to comply with the enablement requirement.

Applicants respectfully submit that, as will be readily appreciated by those skilled in the art, the term F/D ratio relates to a ratio of the array's focal length to its diameter. The term F/D ratio is a well understood term. Applicants have added a brief description of the F/D ratio to paragraph 46 of the specification. Further, Applicants submit that availability of a definition of a F/D ratio is evidenced by information currently available

at http://www.eutelsat.org/business/2_6_2.html#f. Applicants respectfully request that the Examiner reconsider and remove the §112 rejections of claims 36 and 42.

Claim 26 and 40.

Claims 26 and 40 stand rejected under 35 U.S.C. §112 fourth paragraph for not further limiting claims 25 and 39 from which they respectively depend. The Examiner stated that the recited range is broadened over the patent claim.

Applicants respectfully wish to bring to the attention of the Examiner that claims 26 and 40 relate to different directions of the ultrasonic phased array. For example, claim 25 recites that the ultrasonic elements have a dimension in the *azimuthal* direction of about 0.5 to about 7 acoustic wavelengths. However, claim 26 recites that the ultrasonic elements have a dimension in the *elevation* direction of about 0.5 to about 20 acoustic wavelengths. In a similar fashion, claim 39 recites that the ultrasonic elements have a dimension in the *azimuthal* direction of about 0.5 to about 7 acoustic wavelengths. However, claim 40 recites that the ultrasonic elements have a dimension in the *elevation* direction of about 0.5 to about 20 acoustic wavelengths. Accordingly, claim 26 does limit claim 25 while claim 40 limits claim 39. Applicants respectfully request that the Examiner reconsider and remove the §112 rejections of claims 26 and 40.

Rejections Under 35 U.S.C. §102

Claims 1-4, 7, 11, 13-24, 33 and 37-38 stand rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent No. 6,089,096 (hereinafter "Alexandru"). Claim 1, 18 and 37 are independent. All of the recited claims are believed to be patentable as cited below.

Independent Claim 1.

Amended claim 1 recites, *inter alia*, a method for performing an ultrasonic volumetric inspection of a *backscattering* material, comprising the steps of providing an

ultrasonic phased array. The phased array includes a plurality of ultrasonic elements arranged in a rectilinear grid pattern extending in an azimuthal and elevational direction. Modulation is applied to each of the ultrasonic elements to form an ultrasonic scanning beam. At least a portion of the backscattering material is interrogated by directing the ultrasonic scanning beam *via a lens* configured to *provide a desirable F/D ratio* to focus the ultrasonic elements of the ultrasonic phased array *at desirable depths*.

<u>Alexandru does not disclose inspection of backscattering materials.</u>

Claim 1 has been amended to recite a method for performing an ultrasonic volumetric inspection of a *backscattering* material. The techniques of the invention are particularly directed to inspection of such backscattering materials, as evidenced by the following passage from the application:

> When inspecting and/or testing materials which produce a degree of back scattering, such as, for example, titanium, steel or nickel-base super alloys, focusing of the ultrasonic inspection beam enhances the back-reflected signal from flaws contained in the test material and also reduces the noise produced by the test material. This improves the signal to noise ratio (SNR) for all ultrasonic indications, and in turn improves the capability of detecting flaws and the probability of detection (POD), allowing for the detection of flaws having reflectivities equivalent to #1 (1/64") or #2 (2/64") flat bottom holes. Such inspections are often required for aircraft materials, particularly those found in the rotating components of a jet engine.

See, Application, paragraph 2.

As can be seen from this passage, inspections of materials, such as backscattering materials, are often required for aircraft materials, particularly those found in the rotating parts of a jet engine. The inventors have found that in testing and/or inspecting backscattering materials, focusing of the ultrasonic inspection beam enhances the back-reflected signal from defects contained in the backscattering material and also reduces the

noise level produced by the backscattering material. Further, an improved signal-to-noise ratio may be obtained when inspecting and/or testing backscattering materials such as titanium, steel or nickel-based super alloys. Applicants have carefully reviewed Alexandru and respectfully submit that Alexandru does not teach or suggest a method for performing an ultrasonic volumetric inspection of a *backscattering* material.

Alexandru does not teach interrogation of at least a portion of the backscattering material with the ultrasonic scanning beam by directing the ultrasonic scanning beam to provide a desired F/D ratio at desired depths.

The Examiner argued that Alexandru teaches a two-dimensional imaging array having variable focusing abilities in both the azimuthal and elevational directions and an adjustable aperture. Applicants have carefully reviewed Alexandru and respectfully submit that Alexandru does not teach or suggest a method for performing an ultrasonic volumetric inspection of a backscattering material including the step of interrogating at least a portion of the test backscattering material by directing the ultrasonic scanning beam via a lens configured to provide a desirable F/D ratio to focus the ultrasonic elements of the ultrasonic phased array at desirable depths.

Claim 1 has been amended to recite a step for interrogating at least a portion of the backscattering material with the ultrasonic scanning beam by directing the ultrasonic scanning beam to provide a desired F/D ratio at desired depths. Support for this amendment may be found in FIGs. 7-9 and the following cited passages, found in paragraphs 33, 37, 46-50 of the application:

> By applying modulation to individual transducers 102 of aperture 104, an ultrasonic scanning beam 106 can be formed that has the ability to interrogate a portion of a test material to be analyzed (not shown). For example, transducers 102 can be modulated in such a way that scanning beam 106 can be steered and focused as needed.

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As seen in FIG. 4, a focusing lens 108 can be provided which extends across aperture 104 in the Z direction. While lens 108 is shown as extending across all the transducers 102 in the Z direction, it is envisioned and within the scope of the present disclosure to provide a respective lens 108 for each respective transducer 102 or to provide a lens 108 which extends across more than one or multiple transducers 102.

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With reference to FIGS. 7-9, illustrations of various ultrasonic scanning beams producing characteristic focal zones, in accordance with embodiments of the present disclosure are shown. As seen in FIG. 7, array 100 includes a plano-concave lens 108a configured and dimensioned to produce a constant F/D ratio over the operating range of array 100. In particular, lens 108a is configured and dimensioned to manipulate ultrasonic beams 110 to produce uniform sized focal zones "F" in scanning beam 106.

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As seen in FIG. 8, array 100 includes a plano-concave lens 108b configured and dimensioned to produce an increasing F/D ratio over the operating range of array 100. In particular, lens 108b is configured and dimensioned to manipulate ultrasonic beams 110 to produce increasing sized and/or diverging focal zones "F" in scanning beam 106.

As seen in FIG. 9, array 100 includes a plano-concave lens 108c configured and dimensioned to produce a decreasing F/D ratio over the operating range of array 100. In particular, lens 108c is configured and dimensioned to manipulate ultrasonic beams 110 to produce decreasing sized and/or converging focal zones "F" in scanning beam 106.

While FIGS. 7-9 illustrate plano-concave lenses 108a-108c, it is envisioned and within the scope of the present disclosure that plano-concave lenses 108a-108c can be replaced with plano-convex lenses or similarly shaped elements as is consistent with standard practices of ultrasonic transducer design.

Use of a lens 108, preferably a multi-focus lens, such as, for example, a plano-concave lens, on transducers 102, enables pre-focusing of the elevation rows of transducers 102 in order to allow a larger elevation pitch, and to thereby reduce the overall active channel count needed to

> produce apertures 104 of sufficient size to generate the focal properties needed for the inspection and/or testing. It is envisioned that array 100 can be provided with lens 108, having multiple sections of concave, linear, and convex shape, that can be used in combination with a corresponding azimuthal electronic focus to generate lenses that are comparable to the spherical, axicon and toroidal focal geometries of single element conventional transducers.

As can be seen from these passages, the backscattering test material may be interrogated by *steering and focusing* the ultrasonic scanning beam. The ultrasonic scanning beam may be steered and focused by adding an acoustic lens to the transducers 102 in the Z direction (*see*, e.g., paragraph 43) to provide a desired F/D ration at a desired depths. In an exemplary embodiment illustrated in FIGs. 7-9, a plano-concave lens has been employed to steer and focus the ultrasonic scanning beam.

As illustrated in FIG. 7, the plano-concave lens 108a may be configured and dimensioned to produce a *constant F/D ratio* over the operating range of the array 100. In particular, the plano-concave lens 108a has been configured and dimensioned to maneuver ultrasonic beams 110 to produce *uniform sized* focal zones "F" in the scanning beam 106.

FIG. 8 illustrates an embodiment where the plano-concave lens 108b may be configured and dimensioned to produce an *increasing F/D ratio* over the operating range of the array 100. In other words, the plano-concave lens 108b is configured and dimensioned to control ultrasonic beams 110 to produce *increasing sized* and/or *diverging* focal zones "F" in the scanning beam 106.

Further, as depicted in FIG. 9, the plano-concave lens 108c may be configured and dimensioned to produce a *decreasing F/D ratio* over the operating range of the array 100. In particular, the plano-concave lens 108c is configured and dimensioned to control

ultrasonic beams 110 to produce *decreasing sized* and/or *converging* focal zones "F" in the scanning beam 106.

Consequently, the use of the various embodiments of the plano-concave lens 108, advantageously enables pre-focusing of the elevation rows of the transducers 102 in order to allow a larger elevation pitch, and to thereby reduce the overall active channel count needed to produce apertures 104 of sufficient size to generate the focal properties needed for the inspection and/or testing. On the contrary, the use of a concave lens results in the scanning beam 106 converging at one point instead of at multiple points as illustrated in FIGs. 7-9.

Applicants have carefully reviewed Alexandru and respectfully submit that Alexandru does not teach or suggest a method for performing an ultrasonic volumetric inspection of a backscattering material by interrogating at least a portion of the backscattering material with the ultrasonic scanning beam by directing the ultrasonic scanning beam to provide *a desired F/D ratio at desired depths* via the use of the various embodiments of the plano-concave lens 108.

For the reasons summarized hereinabove, Applicants respectfully submit that Alexandru cannot anticipate claim 1. Accordingly, Applicants respectfully submit that independent claim 1 and claims depending therefrom are allowable and respectfully request the Examiner to reconsider rejection of the claims.

Independent Claim 18.

Amended claim 18 recites, *inter alia*, an ultrasonic phased array for inspecting a backscattering material, where the phased array comprises a plurality of ultrasonic elements arranged in a rectilinear grid pattern extending in an azimuthal and elevational direction. Each ultrasonic element is individually addressable and controllable to manipulate the

formation of an ultrasonic scanning beam in both the azimuthal and elevational directions and to produce focal characteristics throughout the volume of the backscattering material.

As discussed above for claim 1, the Examiner relied upon Alexandru for teaching an ultrasonic phased array for inspecting a backscattering material as claimed. However, claim 18 is believed to be patentable for the same reasons set forth above with respect to claim 1. That is, Applicants respectfully submit that Alexandru does not teach the recitations of independent claim 18. Accordingly, Applicants respectfully submit that Alexandru cannot anticipate independent claim 18 or the claims depending therefrom. Applicants respectfully request the Examiner to reconsider rejection of the claims.

Independent Claim 37.

Amended claim 37 recites, *inter alia*, an ultrasonic phased array for inspecting a backscattering material, where the phased array comprises a rectilinear array of ultrasonic elements extending in an azimuth and an elevation direction. Each ultrasonic element is configured to emit a divergent ultrasonic scanning beam which divergent ultrasonic scanning beams combine to form a single ultrasonic scanning beam. The divergent ultrasonic scanning beams formed in an azimuth-depth plane define multiple focal zones in the azimuth-depth plane. Divergent ultrasonic scanning beams formed in an elevation-depth plane define multiple focal zones in the elevation-depth plane.

As discussed above for claim 1, the Examiner relied upon Alexandru for teaching an ultrasonic phased array for inspecting a backscattering material as recited in claim 37. However, in view of the above arguments discussed with reference to independent claim 1, claim 37 is believed to be clearly patentable over Alexandru. That is, Applicants respectfully submit that Alexandru does not teach the recitations of independent claim 37 and, consequently, cannot anticipate independent claim 37 or the claims depending therefrom. Applicants respectfully request the Examiner to reconsider rejection of the claims.

Rejections Under 35 U.S.C. §103

Claims 5-6, 12, 34-36 and 41-42 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Alexandru as applied to claims 1-4, 7, 11, 13-24,33 and 37-38, and further in view of Applicants' admissions. Claims 5, 6, and 35 have been canceled. Applicants respectfully submit that claim 12 is believed to be patentable as it depends from allowable independent claim 1. In addition, claims 34 and 36 are believed to be patentable as they depend from allowable independent claim 18. Further, claims 41-42 are believed to be patentable as they depend from allowable independent claim 37.

Claims 8-10 and 27-32 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Alexandru as applied to claims 7 and 18, and further in view of U.S. Patent No. 5,305,756 (hereinafter "Entrekin"). Applicants respectfully submit that claims 8-10 are believed to be patentable as they depend from allowable independent claim 1. In addition, claims 27-32 are believed to be patentable as they depend from allowable independent claim 18.

Claims 25-26 and 39-40 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Alexandru as applied to claims 18 and 37, and further in view of U.S. Patent No. 4,890,268 (hereinafter "Smith"). Applicants respectfully submit that claims 25-26 are believed to be patentable as they depends from allowable independent claim 18. In addition, claims 39-40 are believed to be patentable as they depend from allowable independent claim 37.

Conclusion

In view of the remarks and amendments set forth above, Applicants respectfully request allowance of the pending claims. If the Examiner believes that a telephonic interview will help speed this application toward issuance, the Examiner is invited to contact the undersigned at the telephone number listed below.

Respectfully submitted,

Date: September 19, 2005

PSY

Patrick S. Yoder
Reg. No. 37,479
FLETCHER YODER
P.O. Box 692289
Houston, TX 77269-2289
(281) 970-4545